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Effect of the different host plants and an artificial diet on the growth parameters of fall armyworm, *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae)

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ABSTRACT

The destructive lepidopteran pest, fall armyworm, *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae) showed resistance to various groups of insecticides. This necessity is taking priority by identifying FAW's preferred hosts and this study primarily focused on assessing the impact of different host plants and an artificial diet composed of chickpea powder, wheat germ and corn flour on various nutritional indices and biotic potential parameters of the FAW under laboratory conditions at the Department of Entomology, Rajasthan College of Agriculture, Udaipur. Under the study, it was reported that FAW larvae completed the lifecycle in 35.92 ± 0.33 days within the host maize.

Key words: *Fall armyworm, Hosts, Instars, Biotic potential, Oviposition*

Introduction

The fall armyworm, *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae), is one of the most important lepidopteran pests of maize crop, identified as sporadic, polyphagous and migratory pest species in the world (Hardke *et al*., 2015). In India, *S. frugiperda* (J.E. Smith) was first reported in 2018 from the Indian subcontinent (Ganiger *et al*., 2018; Sharanabasappa *et al*., 2018), in Karnataka (ICAR-NBAIR, 2018a) and Andhra Pradesh (EPPO, 2018). The pest has also been reported in Bihar, Chhattisgarh, Gujarat, Rajasthan, Maharashtra, Odisha, Tamil Nadu, Andhra Pradesh, Telangana, Madhya Pradesh and West Bengal (ICAR-NBAIR, 2018b; EPPO, 2019).

Fall armyworm is endemic in different agro-ecosystems mainly due to its wide host range, high ability to spread, long-distance migration, high fecundity, short life cycle and favourable climatic conditions (Montezano *et al*., 2018; FAO, 2019). It can feed and complete its life cycle in any plant other than its main host, having high CN content (Fang *et al*., 2022). More than 353 species in 76 families (Poaceae; 106, Asteraceae; 31, Fabaceae; 31), including many economically significant crops, such as maize, sor-

ghum, rice, wheat, barley, oats, millets, ryegrass, faba beans, soybeans, potato, tomato, tobacco, cotton, peanut, sugarcane, alfalfa and onion are consumed by *S. frugiperda* (Montezzano *et al*., 2018; Sun *et al*., 2021; Kenis *et al*., 2022). The difference in tissue structure, nutritional components and metabolites of host plants will significantly affect the pest's growth, development, survival and reproduction (Acharya *et al*., 2022; Lu *et al*., 2023). Thus the pest will be responding differently to different host plants (Huang *et al*., 2019; Wang *et al*., 2023).

The survival, growth, and reproduction of phytophagous insects are significantly influenced by the chemical compositions of their host plants. Lepidopteran insects, like other insects, exhibit responses to suboptimal diets, including adjusting food intake, changing food sources, and modulating nutritional efficiency. A study by Nandhini *et al.* (2023) examined the biology of fall armyworm on various plant parts, including maize leaves, maize cob, sorghum leaves, castor leaves, cowpea leaves, banana leaves, and marigold flowers. They found that fecundity, hatchability, and survivability were higher in the FAW reared on maize leaves, followed by the maize cob, where larval duration is the shortest.

Fall armyworm populations have developed high resistance to various insecticides due to their polyphagous nature. This resistance is a growing concern due to environmental risks and the need for economically efficient and sustainable pest control methods. La Rossa *et al.* (2013) suggest that host preference is an environmentally friendly method used in integrated pest control frameworks. Therefore, developing effective and economical management strategies for controlling *S. frugiperda* is crucial to address this issue.

Since information on effective prevention and control strategies for fall armyworms is lacking, it is necessary to understand how this pest will adapt to different host plants and their biotic potential. This will be a reference for determining fall armyworms' suitable control techniques and reproductive potential.

Materials and Methods

The selected host plants included maize (*Zea mays* L.) and soybean (*Glycine max*). The seeds were sown in plastic pots with soil. The healthy 25-30 day-old plants were used for the experiment. The larvae were collected from the Instructional maize field and were reared individually in containers for two generations on corn leaves before being used in the experiment. The insects were maintained in the laboratory at 25±2 ºC and 60-70% relative humidity, with a photoperiod of 14:10 (L:D) h. The artificial diet was used in this experiment as per modification of Nalin (1991) by Pinto *et al.* (2019). The diet consisted of a mixture of nutritive substances, including carbohydrates, proteins, fats, minerals and vitamins; each had a specific function in the insect and safe shelf life of the constituted diet.

All the powder ingredients were weighed using an electronic balance and mixed to form a paste with the help of a mixer. Agar was boiled after cold distilled water was added to it and mixed with the paste. Tetracycline, formaldehyde, and vitamin solution were added to this mixture. The diet was then transferred to a vial and refrigerated after being covered with a polythene cover.

Twenty newly hatched larvae were reared individually on different host plants. Younger leaves were given to third and fourth-instar larvae, whereas older leaves were given to the later instars. The larvae were examined regularly to record different biological parameters, such as the larval period, pupal period, adult period and total life cycle (Nandhini *et al*., 2023).

Statistical Analysis

The parametric data were analyzed using one-way ANOVA (Analysis of Variance), and mean separation was conducted using Tukey's test at a 5% significance level.

Results

Fall armyworms (FAW) have completed the entire life cycle on an artificial diet and all three host plants. There are six instars in larval development irrespective of the host plants. Table 1 and shows the effect of artificial diet, maize, soybean on the biotic potential parameters of *Spodoptera frugiperda*. The duration of the first instar larvae of FAW varied across different host plants and artificial diet treatments. Maize and soybean supported quicker development, with 2.24 days (± 0.09) and 2.38 days (± 0.16), respectively. On the artificial diet, the larvae took approximately 3.29 days (± 0.10) to complete the first instar stage. From Table 1 it is evident that, second, third, and fourth instar larval durations were not significantly different in the case of maize,

artificial diet, and soybean, with the shortest values in maize (2.12 ± 0.07, 2.16 ± 0.07, and 2.48 ± 0.13 days, respectively). In soybean, the durations of the second, third, and fourth larval instars were 2.52 (±0.13), 2.57 (±0.15), and 2.71 (±0.17) days, respectively. Meanwhile, on an artificial diet, these durations were recorded as 2.62 (± 0.13), 2.52 (± 0.15), and 2.57 (± 0.11) days, respectively. The 5th instar larvae fed on an artificial diet exhibited 3.19 days (± 0.09), while those reared on maize and soybean showed the shortest and similar duration of 2.52 days (± 0.11). There is no significant difference in the 6th instar duration of FAW on maize and soybeans. The shortest duration was recorded on maize (3.24±0.17days), while on soybean; it was slightly long 3.29 (±0.17) days. The 6th instar larval duration on the artificial diet was the longest and had a mean duration of 4.62 days (± 0.12).

From Table 1, it is clear that total larval developmental duration was significantly varied among different host plants, shorter on maize (14.76 ± 0.22 days). No significant difference in the total larval duration between soybean (16.00 ± 0.39 days) and maize. The total larval duration on the artificial diet was 18.81 days ± (0.34). The pre-pupal duration of FAW was significantly shorter on maize (1.20± 0.08 days) and longer on artificial diet (2.29±0.10 days). The pupal duration ranged from 8.04 to 11.43 days (Table 1), with the shortest duration observed on maize (8.04 ± 0.16 days). On an artificial diet, the pupal duration was 10.14 days (±0.20). Adult longevity varied across different host plants (Table 1), with FAW adults being long-lived in soybean (12.57 ± 0.36 days) and short-lived in maize (8.92 ± 0.28 days). The adult developmental duration of FAW didn't significantly differ on artificial diet (12.05±0.16 days), soybean (12.57±0.36 days). However, maize took 8.92 days (±0.28) to complete the adults age of FAW. FAW completed the whole life cycle in a short period on maize (35.92± 0.33days) compared to soybean (41.91±0.55 days) and artificial diet (46.29±0.35days).

Discussion and Conclusion

In this study, the biotic potential and nutritional indices of FAW were examined in an artificial diet and on eight different host plants like, maize and soybean. The study clearly shows the varied performance of *S. frugiperda* in larval and pupal developmental periods, adult longevity and total lifespan, when artificial diet and different host plants were offered as the food for the larvae.

In general, short developmental durations, high survival rates and large reproductive capacities of herbivorous insects serve as crucial indicators of their high adaptability to host (Moreau *et al*., 2006). The larval development of *Spodoptera litura* was found to vary based on the host plants and temperature conditions (Zhu *et al*., 2000). In the present study, the duration of the first instar larvae was the shortest on maize. Subsequently, the second, third and fourth instars larval durations were briefest on maize. In the fifth instar, maize and soybean sup-

Table 1. Developmental period (days) of the larval instars, pre-pupa, pupa and adult stage and total lifespan of *S. frugiperda* fed with an artificial diet and leaves of different host plants.

Parameters	Host plants		
	Artificial diet	Maize	Soybean
1st instar (d)	3.29 ± 0.10^{bc}	2.24 ± 0.09^{d}	2.38 ± 0.16^{d}
2nd instar (d)	2.62 ± 0.13^{c}	2.12 ± 0.07^{c}	2.52 ± 0.13^{c}
3rd instar (d)	2.52 ± 0.15^{d}	2.16 ± 0.07^{d}	2.57 ± 0.15^{d}
4th instar (d)	2.57 ± 0.11^{d}	2.48 ± 0.13^{d}	2.71 ± 0.17^{d}
5th instar (d)	3.19 ± 0.09^{d}	2.52 ± 0.10^{e}	2.52 ± 0.11^{e}
6th instar (d)	4.62 ± 0.12^{d}	3.24 ± 0.17^{e}	3.29 ± 0.17^{e}
Total larva (d)	18.81 ± 0.34^{e}	14.76 ± 0.22^{f}	16.00 ± 0.39^{f}
Pre-pupa (d)	2.29 ± 0.10^{c}	1.20 ± 0.08^{d}	1.29 ± 0.10^{d}
Pupa (d)	10.14 ± 0.20^{c}	8.04 ± 0.16^{d}	9.05 ± 0.22^{cd}
Adult (d)	12.05 ± 0.16^{a}	8.92 ± 0.28^{b}	12.57 ± 0.36^{a}
Total lifespan (d)	46.29 ± 0.35^{c}	35.92 ± 0.33^{e}	41.91 ± 0.55^{d}

Data are presented as the mean ± SE. The mean followed by different letters within columns for each variable are significantly different using Tukey's test (P d" 0.05).

ported the shortest duration. The sixth instar larvae exhibited a short duration on maize. In the current study, maize's total larval developmental duration was shorter than other crops under study. However, it was approximately 20 days longer than in maize. Sarate *et al*. (2012) observed that *Helicoverpa armigera* exhibited faster growth and achieved greater biomass when reared on maize. Conversely, larvae experienced delayed development and increased mortality when reared on marigolds and rose. The extended duration of FAW instars suggests that these plants may be less nutritionally adequate than maize, artificial diet and soybean.

Similarly, the pupal duration was also shortest on maize by 4 days. The pupal characteristics such as pupal duration, weight and size are often indicative of the fitness and nutritional status of a larva (Soto *et al*., 2018). The present results are in line with the results of Rajisha *et al*. (2021), who documented that the pupal stage of FAW lasted approximately 8-11 days when reared on maize.

The longevity of male and female adults on maize was 7-9 and 9-12 days, respectively (Sharanabasappa *et al*., 2018). The adult of the FAW larvae fed on soybean survived longer than on any other hosts studied. Chen *et al*. (2020), observed a life cycle ranging from 37-40 days when reared on maize. Completion of the whole lifecycle of FAW larvae was significantly shorter on maize. In the current study, it was observed that FAW completes its entire life cycle on maize within 35.92 days, similarly, it was reported by He *et al*. (2021) that the life cycle of FAW on maize plants was 41.5 days.

Conflict of Interest - None

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